Remarks

I. Specification

The Office Action asserts that the title of the invention is not descriptive. The title of the invention is thus modified to be clearly indicative of the invention to which the claims are directed:

~~NANOTUBE DEVICES AND METHOD OF FABRICATION BY MAGNETICALLY ASSISTED ASSEMBLY~~

NANOTUBE WITH AT LEAST A MAGNETIC NANOPARTICLE ATTACHED TO THE SIDEWALL AND ELECTRONIC DEVICES MADE THEREOF

II. 35 USC 102

The Office Action rejects claims 22, 24 and 26 under 35 USC 102(e) as being anticipated by Shin et al. (U.S. Patent No. 6,515,339). The Office Action states:

> Shin et al. show all aspects of the instant invention (e.g. Figures 6 to 25) including:
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> - A source 210, a drain 220, a gate 230 and a channel 260 including a nanotube of submicron diameter (e. g. Figures 20 and 21 and Column 6 lines 50 to 61 and column 10 Lines 7 to 12)
> - A plurality of electrodes connected to electronic devices and a plurality of conductive interconnects using nanotubes connecting the electrode and devices (e.g. figures 15 to 17).

Applicants have amended claims 22, 24 and 26 to include the limitation that "each nanotube has at least one magnetic nanoparticle attached to the exterior cylindrical surface". This limitation is not taught or suggested in Shin. Additional descriptions are also included to make it more specific as to the location of the attached magnetic nanoparticles with respect to the nanotube. It is clarified that a nanotube has hollow cylindrical shape with an exterior and interior cylindrical surfaces, and the nanotube also has two ends, one or more magnetic nanoparticles are attached to the exterior cylindrical surface of the nanotube. This is a clear distinction to Zhang et al. where nanoparticle may be attached to one or both ends of the nanotube. The mechanism of growing carbon nanotubes using Fe, Co, and Ni particles as catalyst is illustrated in Ref. 1 and 2. In typical carbon nanotube growth process, catalytic particles remain on support structure, and the other end being dome-closed. In this case, only a single catalytic particle is attached to the base end of the nanotube. In another case, a fragment of the catalytic particle may stay atop the

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growing carbon nanotube and end up attached to the other end of the nanotube. In either case, the catalytic particle cannot reside on the cylindrical surface of the nanotube.

III. 35 USC 103

Claims 1 to 5, 23, 25 and 27 are rejected as obvious over Shin et al. and Zhang et al. (U.S. Patent No. 6,764,874). The Office Action notes that Shin et al. show most aspects of the instant invention (Paragraph 7) except for the magnetic nanoparticles attached to the nanotube and not encircled by the nanotube wall and made of Co, Ni or Fe. Zhang et al. teach (e.g. Figure 9) to attach Ni, Co or Fe magnetic nanoparticles 53 to nanotubes 58 to form nanotubes at lower temperatures and precise alignment (Column 8 Lines 15 to 30). It would have been obvious to a person of ordinary skill in the art at the time of invention to attach Ni. Co or Fe magnetic nanoparticles to nanotubes as taught by Zhang et al. in the device of Shin et al. to form nanotubes at lower temperatures and precise alignment.

Applicants have cancelled claims 23, 25 and 27, and amended claims 1, 2, 22, 24, 26 to include the limitation that "each nanotube has at least one magnetic nanoparticle attached to the exterior cylindrical surface". This limitation is not taught or suggested in Shin or Zhang. In order to understand the fundamental difference between our patent and U.S. 6,764,874 by Zhang et al., it is important to point out that Ni, Fe/Co alloy, and Fe/Ni alloy are used as catalyst in the growth of nanotube in CVD (chemical vapor deposition) process. As described by Zhang et al. in column 4 lines 35 through 46, upon applying heat up to 800 °C, Al supporting layer melts and form small droplets and oxidized to form Al2O3 particles, which serves as support for Ni catalytic nanoparticles when Ni catalyst film reacts to heat. Sufficient hydrocarbon gas flow and pressure is needed to provide carbon to form supersaturated Ni carbide needed for initiating carbon nanotube growth. As discussed in column 6 lines 34-36 in Zhang, the growth of carbon nanotubes proceeds until the desired length of the carbon nanotubes is reached. As a result of this process, the catalyst nanoparticles of Ni, Fe/Co, or Fe/Ni can only be attached to either end of a nanotube. In fact, such configuration of nanoparticles and nanotubes is illustrated in Figs. 15-19 by Zhang et al. Consistent with the embodiment, Zhang et al. claimed methods of fabricating nanotube structures comprising the step of forming at least one single walled nanotube on the surface wherein the at least one single walled nanotube is formed from at least one of the plurality of active catalyst nanoparticles. A catalyst nanoparticle from which a carbon nanotube

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grows can only be attached to the ends of the CNT, and cannot be attached to the exterior cylindrical surface of the CNT. In summary, the limitation that the nanotube has at least one magnetic nanoparticle attached to exterior cylindrical surface is not taught or suggested by Zhang. As described in the embodiment of our invention, the magnetic nanoparticles are attached to chemically functionalized sidewall surface of CNT only for the purpose of manipulating and assembling carbon nanotubes to form functional devices.

Applicants respectfully disagree with the Office Action assertion that it "would have been obvious to a person of ordinary skill in the art at the time of invention to attach Ni, Co or Fe magnetic nanoparticles to nanotubes as taught by Zhang et al. in the device of Shin et al. to form nanotubes at lower temperatures and precise alignment". Based on remarks made above, nanoparticles can only be attached to the end surface of nanotubes both as suggested in Zhang and as a result of the method taught by Zhang. Zhang would not have anticipated nanoparticles attached to exterior cylindrical surface of a nanotube in currently amended claims 1, 2, 22, 24, 26. The alignment of the nanotubes may be achieved with an electric field during chemical vapor deposition processing as suggested by Zhang (Column 8, lines 28-30). The alignment of nanotubes is achieved by applying electric field, independent of existence of magnetic nanoparticles attached. There is no suggestion made by Zhang that the two are linked. On the other hand, as suggested in the summary section and throughout the detailed description section of our patent that attachment of magnetic nanoparticles is the means to achieving aligned nanotubes via application of aligning magnetic field. Therefore, the amended claims 1, 2, 22, 24, and 26 are non-obvious to those of ordinary skill in the art.

Claims 3 is a dependent claim of claim 2, and claims 4 and 5 are dependent claims of claim 1. Both claims 1 and 2 have been amended to include the limitation described above, which is not taught or suggested by Shin or Zhang.

Claim 28 is a dependent claim of claim 26, which has been amended to include the limitation that the nanotube has at least one magnetic nanoparticle attached to the exterior cylindrical surface. As discussed above regarding claim 22, this limitation is not taught or suggested in prior arts by Shin et al, and Honlein et al.

In short, applicants have amended claims 1, 2, 22, 24, 26 to include the limitation that "each nanotube has at least one magnetic nanoparticle attached to the exterior cylindrical

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surface". As discussed above regarding claim 1, this limitation is not taught or suggested in Shin, Zhang and Honlein.

Claims 3, 4, 5, and 28 are non-obvious over Shin, Zhang, and Honlein for at least the reasons given above with regard to claim 1.

Office action noted that Mao et al. teach to have nanoparticles 104 "attached" to the exterior wall of nanotubes 105 to hold or trap the nanotubes onto a substrate. Applicants noted that Mao et al. claimed a field emission cathode material comprising a mixture of carbon nanotubes and particles. There is obvious difference between a mixture of carbon nanotubes and particles with a carbon nanotube with magnetic nanoparticles attached to the exterior cylindrical surface as claimed in this invention by the applicants. A carbon nanotube with attached magnetic nanoparticles forms an independent entity by itself. The word "attach" means there is a bond between the nanotube and the nanoparticle; whereas, mixture means "an aggregate of two or more substances which are not chemically united and which exist in no fixed proportion to each other" (Webster's Encyclopedic Unabridged Dictionary of the English Language 1st Edition, 1989). Secondly this invention discloses and claims magnetic nanoparticles as the key element to the functional applications of the devices. Magnetic nanoparticle is not part of functional features in Mao et al, and is therefore not mentioned or claimed.

References:

1) "Growth mechanisms in chemical vapour deposited carbon nanotubes", V. Vinciguerra, F. Buonocore, G. Panzera, and L. Occhipinti, Nanotechnology 14 (2003) 655-660.

2) "The current status of carbon nanotubes science & technology", Prof. Hongjie Dai, Nanoscience & Nanotechnology Workshop, Stanford Engineering & Science Institute, July 26-30, 2004.

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II. Conclusion

Applicants have responded to the Office Action by amending some of the claims and by showing that the Office Action has not presented a prima facie case of obviousness for any of the claims. As such, applicants respectfully assert that the application is in condition for allowance, and a notice of allowance is solicited.

Respectfully submitted,

CERTIFICATE OF MAILING

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to the Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on June 9, 2005.

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Yingjian Chen

Yingjian Chen
1123 Wisteria Drive
Fremont, CA 94539

Tel: (510) 449-7813
Fax: (510) 490-6426

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